

# BMJ Open Effectiveness of solar disinfection water treatment method for reducing childhood diarrhoea: a systematic review and meta-analysis

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## ABSTRACT

**Objective** This study aimed to pool out the available evidence on the effectiveness of the solar disinfection water treatment method for reducing childhood diarrhoea.

**Design** Systematic review and meta-analysis.

**Setting** Global.

**Methods** Searches were conducted in Medline/PubMed, Scopus, Google Scholar, Cochrane Library databases and references to other studies. The review included all children living anywhere in the world regardless of sex, ethnicity and socioeconomic status published in English until December 2019. Studies that compared the diarrhoea incidence between the intervention group who were exposed to solar disinfection water treatment and the control group who were not exposed to such water treatment were included. The outcome of interest was the change in observed diarrhoea incidence and the risk from baseline to postintervention. Two independent reviewers critically appraised the selected studies. Effect sizes were expressed as risk ratios, and their 95% CIs were calculated for analysis.

**Results** We identified 10 eligible studies conducted in Africa, Latin America and Asia that included 5795 children aged from 1 to 15 years. In all identified studies, solar disinfection reduced the risk of diarrhoea in children, and the effect was statistically significant in eight of the studies. The estimated pooled risk ratio of childhood diarrhoea among participants that used the solar disinfection water treatment method was 0.62 (95% CI 0.53 to 0.72). The overall pooled results indicated that the intervention of solar disinfection water treatment had reduced the risk of childhood diarrhoea by 38%.

**Conclusions** The intervention of solar disinfection water treatment significantly reduced the risk of childhood diarrhoea. However, the risk of bias and marked heterogeneity of the included studies precluded definitive conclusions. Further high-quality studies are needed to determine whether solar disinfection water treatment is an important method to reduce childhood diarrhoea.

**PROSPERO registration number** CRD42020159243

## INTRODUCTION

Diarrhoea is the second leading cause of death in children under 5 years of age, and an estimated 2.5 billion cases of diarrhoea

## Strengths and limitations of this study

- Study selection, data extraction and quality assessment were independently performed by two review authors.
- This review was the first meta-analysis done on solar disinfection, water treatment methods and the risk of childhood diarrhoea.
- The limitations of this study were, we tried to include only published articles, excluding unpublished articles/resources and restrictions to studies written in English.

occur and are responsible for killing around 760 000 children every year. More than half of these cases are in Africa and South Asia, where the attacks of the diseases are more likely to result in death or other severe outcomes.<sup>1</sup> This diarrhoea-related death in low-income and middle-income countries is mostly attributable to inadequate water, sanitation and hygiene.<sup>2</sup> The deaths of 279 000 children aged under 5 each year could be avoided if the risk factors were addressed.<sup>3</sup> Previous systematic review findings suggest that point-of-use water treatment is one of the most effective strategies to reduce diarrhoea among children under 5 years of age.<sup>4–7</sup>

The importance of household water treatment and safe storage (HWTS) in reducing diarrhoeal disease has been increasingly recognised.<sup>8–9</sup> Solar disinfection (SODIS) method is recognised as one viable HWTS option.<sup>10</sup> It is the simplest, cheapest technology, and effective water treatment method that applies to emergencies, especially when no chemical disinfectants are available.<sup>11</sup> The method relies on disposable transparent plastic or glass containers which are then exposed to the sun and its germicidal effect is based on the combined effect of thermal heating of solar light and UV radiation.<sup>12–14</sup>

Since SODIS is simple to use and inexpensive, the method has spread throughout the low-income and middle-income world and is in daily use in >50 countries in Asia, Latin America and Africa. More than 5 million people disinfect their drinking water with the SODIS technique as the report of a systematic review.<sup>14</sup>

SODIS has been repeatedly shown to be effective for eliminating microbial pathogens and reducing diarrhoea morbidity, but its effectiveness is limited to waters of low turbidity.<sup>12–15</sup> Earlier cluster-randomised controlled trial studies showed that the SODIS of drinking water reduced diarrhoea among under-5 children.<sup>16–18</sup> A matched case-control study done in India also concludes that SODIS of water can significantly decrease diarrhoea morbidity in children.<sup>19</sup> Other study findings reported from Kenya showed that children drinking solar disinfected water had a significantly lower risk of severe diarrhoeal disease over 8705 2 weekly follow-up visits; the 2 weeks prevalence of diarrhoea in the intervention group was 48.8% compared with 58.1% in controls, corresponding to an attributable fraction of 16.0%.<sup>17</sup> Studies reported from Bolivia and Peru showed that there was no statistically significant difference in the number of diarrhoea episodes between the SODIS and control arms of the study.<sup>18–20</sup>

Other studies showed that SODIS was essential among household water treatment and safe storage for the reduction of diarrhoea. However, the reported findings revealed heterogeneous outcomes. More importantly, a systematic review and meta-analysis have not been done to pool the evidence of the effectiveness of the SODIS water treatment method for reducing diarrhoea. Therefore, the objective of this review was to pool out the available evidence on the effectiveness of the SODIS water treatment method for reducing diarrhoea. The research question of this review was ‘Does solar disinfection water treatment method improve the microbial quality of drinking water and reduce childhood diarrhoea?’

## METHODS

### Protocol development

This systematic review and meta-analysis has been written following the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) statement guidelines<sup>21</sup> (see online supplemental file 1). Before undertaking the review, we registered the protocol in PROSPERO (CRD42020159243) and the detail of this systematic review and meta-analysis protocol has been published elsewhere.<sup>22</sup>

### Data sources and search strategy

An electronic database search was carried out to identify appropriate peer-reviewed articles that met the inclusion criteria. We searched PubMed/Medline, Scopus, Google Scholar, Cochrane Library databases and references to other studies. We used a combination of Medical Subject Heading terms and keywords terms: (solar energy OR sunlight) AND (water disinfection OR water purification

OR water treatment) AND (diarrhea OR diarrhoea OR dysentery) AND (children OR child OR childhood). The search of the literature was conducted in December 2019. The search strategy was limited to studies published in English language literature (see online supplemental file 2: full search strategy for PubMed/Medline and Cochrane library databases). The results of the search and the full process for selecting included the studies were reported and presented in a PRISMA flow diagram.<sup>23</sup>

### Criteria for considering studies for this review

Studies that met the following criteria were included in this review.

#### Types of studies

We included only randomised controlled trials studies that assessed the effectiveness of the SODIS water treatment methods for reducing diarrhoea and published in English until December 2019.

#### Participants

The review included all children living anywhere in the world regardless of sex, ethnicity and socioeconomic status.

#### Interventions and comparator

This review considered studies that evaluated the effectiveness of SODIS as a water treatment method for the reduction of diarrhoea. Studies that compared the diarrhoea occurrence among the intervention group children who were exposed to SODIS water treatment and control group children who were not exposed to such water treatment were considered.

#### Types of outcome measures

This review considered studies that included the incidence rates of diarrhoea (non-bloody, with dehydration, dysentery), defined as the number of diarrhoea (three or more loose or watery stools during 24 hours or any loose stool that contained blood or mucus) episodes per child per year obtained from a daily assessment of the individual diarrhoea occurrence. The primary outcome of this study was the change observed in diarrhoea incidence after SODIS was applied for the treatment of drinking water.

### Data collection and analysis

#### Data management and selection of studies

Mendeley Desktop reference management software V.1.19.5 (Mendeley, Elsevier, The Netherlands) was used to combine search results and to remove duplicate articles. Two independent reviewers (NES and DOD) conducted the screening of included studies. The articles found by searches in databases were evaluated for inclusion at three levels, that is, by title, then by abstract and finally by full text. The full text of selected studies was retrieved and assessed in detail against the inclusion criteria. Discrepancies were discussed between reviewers and agreement was reached about whether to include the study or not. For the screening of articles at the full-text level, rejection of an

article was decided by the review team on the suggestion of the first reader. The details regarding the final decision of inclusion of articles were clarified and archived in a database. In case of uncertainty in the decision, whether to include the study or not, the reviewer included this article for the next level of screening. The documents without abstracts were screened at the full-text level. A list of articles excluded at the full-text level was provided in the systematic review, accompanied by reasons for exclusion.

### Data extraction

The data were extracted from studies included in the review using the prepared data extraction tool form by two independent review authors (NES and DOD). For each study, the authors' name, place and year of publication, data on sample size and characteristics, characteristics of interventions performed, results of included studies, and follow-up of the study were extracted. The data extraction form was pretested with three randomised controlled trials similar to those eligible in this review. Any disagreements that arise between the reviewers were resolved through discussion or with a third reviewer (BMA).

### Risk of bias of included studies

The methodological quality of the studies that met the selection criteria were evaluated independently by two authors (NES and DOD) using the revised Cochrane risk-of-bias tool for randomised trials outlined in the Cochrane Handbook for Systematic Reviews of Interventions.<sup>24</sup> This method classifies bias in randomised studies as 'low', 'high' or 'unclear' based on the presence or absence of six processes (random sequence generation, allocation concealment, blinding participants or investigators, incomplete outcome data, selective reporting and other biases). These were identified based on both empirical evidence and theoretical considerations. The rating for each bias criterion of the two authors was compared. Disagreements between the two authors on individual bias criteria were identified and discussed in an attempt to reach a consensus. Any disagreements that arose between the reviewers were resolved through discussion or in consultation with a third reviewer.

### Measures of treatment effect

It is expected that SODIS water treatment intervention reduces the risk of diarrhoea, and we used the risk ratio (RR). RR was estimated by using the following data: the number of participants who experienced diarrhoea and the total number of participants in each group.  $RR < 1$  indicated that SODIS water treatment results in a greater chance of decreasing diarrhoea.

### Dealing with missing data

We contacted the authors for missing data and clarity of primary studies if required; such inclusions were reported in the review.

### Data synthesis and assessment of heterogeneity

We conducted a narrative synthesis first to describe the study details, participant and intervention characteristics and outcomes of the included studies. Then meta-analysis was conducted using Comprehensive Meta-Analysis V.3.3 (Biostat, USA). We calculated 95% CIs and two-sided *p* values for the outcome. Heterogeneity was assessed using the Cochrane  $\chi^2$  test (Q-test) statistics and inverse variance index ( $I^2$ ) statistics. An  $I^2$  value, a measure that ranges from 0% to 100%, was classified as follows: no relevant heterogeneity (0%–25%), moderate heterogeneity (25%–50%) and significant heterogeneity (>50%).<sup>25</sup> A high degree of heterogeneity was observed for the outcome, and thus, we used a random-effects model to estimate the pooled RR. Forest plots were generated to present the pooled estimates. In the forest plot, the size of each circle revealed the weight of the study, while each crossed line refers to a 95% CI. Moreover, the diamond represents the overall effect, whereas the width of the diamond shows the CIs for the overall effect estimated. We performed subgroup analyses to investigate the possible sources of heterogeneity using follow-up periods of the studies, the age of the included participants and the region of study settings/continent. The presence of publication bias was examined using a funnel plot and Egger's test. A sensitivity analysis was repeated 10 times after excluding one study using a random-effects model to observe the impact of the individual study on the overall RR.

### Patient and public involvement

No patient involved.

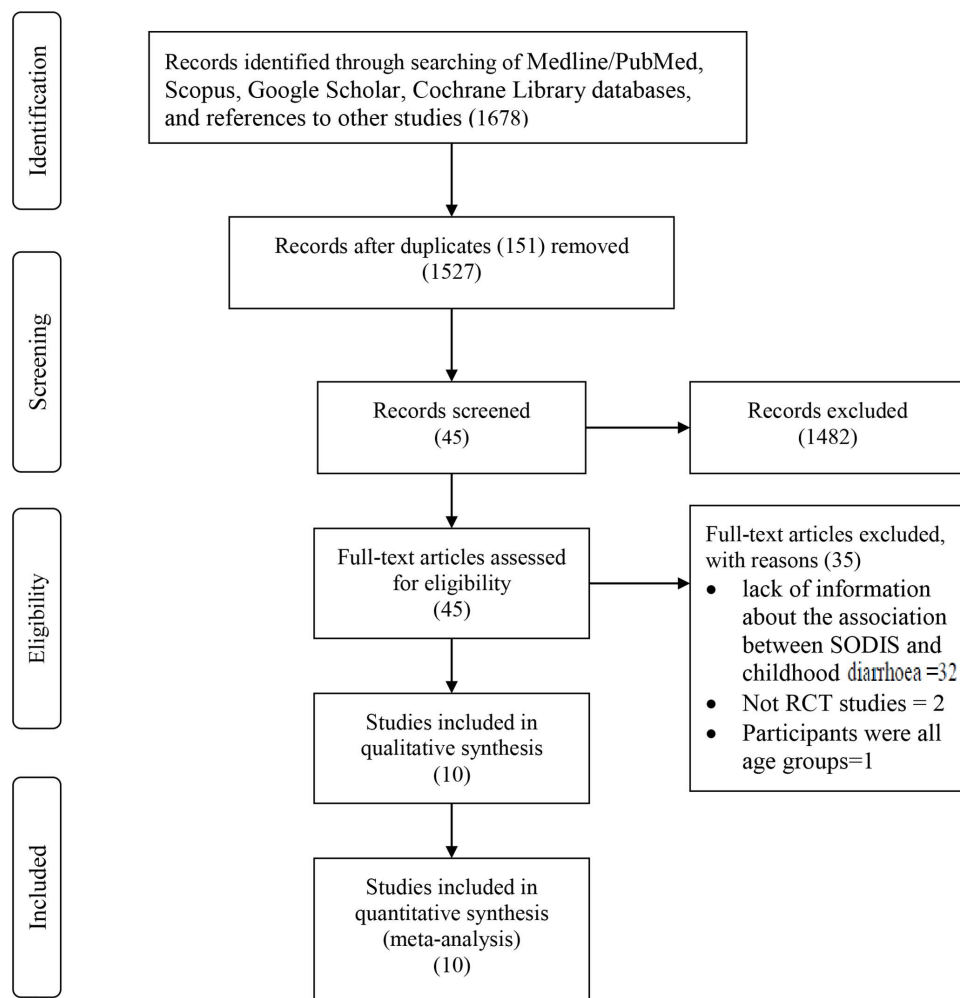
## RESULTS

### Study selection

The search strategy resulted in 1678 records from electronic databases and hand searches. Out of these records, we identified 1527 records after duplicates removed. After reviewing the titles/abstracts, 1482 records were excluded and 45 full-text articles assessed for eligibility. Of the 45 articles selected for potential eligibility, 32 were excluded as they did not relate to our study question. The other three articles were excluded due to their study design and study participants.<sup>26–28</sup> A list of articles excluded at the full-text level and reasons for exclusion are illustrated in online supplemental file 3. The remaining 10 studies were included in the present systematic review and meta-analysis<sup>16–20 29–33</sup> (figure 1).

### Study characteristics

Table 1 summarises the characteristics of the studies included in this meta-analysis. All the included studies were intervention-based studies that were conducted from 1996 to 2018 in seven low-income and middle-income countries. Among the 10 studies, 6 studies were conducted in Africa,<sup>16 17 29–32</sup> 2 studies were conducted in Latin America<sup>18 20</sup> and the remaining 2 studies



**Figure 1** Flow diagram of included relevance studies identified by the systematic search strategy. RCT, randomised controlled trial; SODIS, solar disinfection.

were conducted in Asia.<sup>19–33</sup> Regarding the included studies setting, seven studies were conducted in a rural area.<sup>16–18 20 30–33</sup> The total study participants were 5795 children aged 1–15 years live in households using SODIS and no intervention (table 1).

### Risk of bias in individual studies

Risk of bias assessment is presented in figure 2. Based on the results of the study's risk of bias assessment, we have judged seven studies as having a low risk, two studies were judged as having some concerns and the remaining one study was judged as having a higher risk of bias (figure 2).

### Childhood diarrhoea

SODIS water treatment method reduced diarrhoea in children in all studies identified. After the implementation of the SODIS water treatment method, the risk of childhood diarrhoea was significantly reduced in eight studies with a RR range of 0.16–0.70 at 95% CI. In two studies, childhood diarrhoea was reduced but the reduction was not statistically significant. In this meta-analysis, we found a significant heterogeneity across the studies ( $I^2=74.37%$ ,  $p=0.000$ ). As presented in figure 3, the overall pooled RR of childhood diarrhoea reported by the 10 studies using

the random-effects model was 0.62 (95% CI 0.53 to 0.72). These imply that the effect of diarrhoea was significantly ( $p<0.000$ ) reduced by 38% using the SODIS water treatment method (figure 3).

### Subgroup analysis

The results from subgroup analysis are summarised in figures 4–6. In the figures, the presence of heterogeneity was assessed by subgroup analysis. In figure 4, the level of heterogeneity was decreased for 3 months follow-up and there is no evidence of heterogeneity for 6 months follow-up. We found a RR of diarrhoea reduction by 39% for 3 months, 35% for 6 months and 41% for 12 months follow-up. The pooled RRs for each group were 0.61 (95% CI 0.43 to 0.86) for 3 months follow-up, 0.65 (95% CI 0.48 to 0.87) for 6 months follow-up and 0.59 (95% CI 0.43 to 0.80) for 12 months follow-up (figure 4). The pooled RRs for the subgroup analysis based on the age of study participants were 0.59 (95% CI 0.46 to 0.76) for age <5 years, 0.56 (95% CI 0.34 to 0.92) for age <6 years and there was only one study in the 5–16 and <3 years age groups. In figure 5, the level of heterogeneity was high for ages <5 and <6 years after subgroup analysis (figure 5). Moreover,

**Table 1** Detailed characteristics of study populations

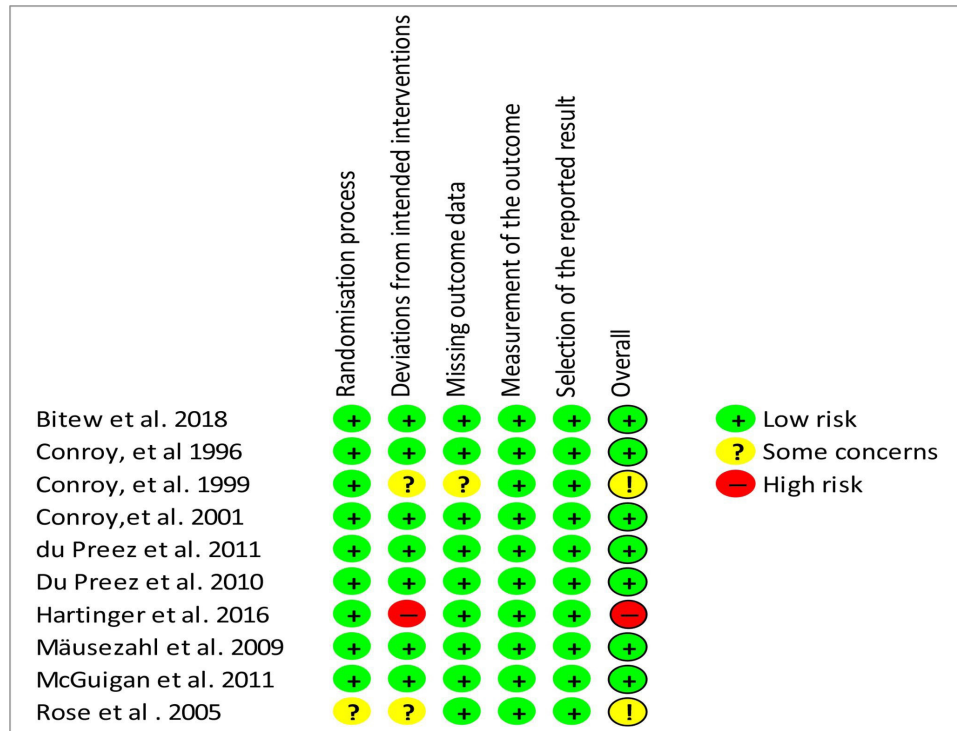
Study	Study setting, country	Number of participants enrolled in the trial		Age groups (years)	Follow-up periods (months)	Intervention	Effect size (95% CI)	Study design	Findings
		Intervention	Control						
Bitew <i>et al</i> <sup>16</sup>	Rural, Ethiopia	384	394	<5	6	POU, solar treatment	0.60 (0.52 to 0.70)	Community-based cluster randomised controlled trial	High risk for faecal contamination of drinking water was brought to low-risk levels. The incidence of diarrhoea was reduced in the intervention group compared with the control.
Conroy <i>et al</i> <sup>31</sup>	Rural, Kenya	155	144	<6	3	POU, solar treatment	0.16 (0.05 to 0.52)	Household randomised controlled trial	The odds of having cholera was reduced in the intervention group compared with controls.
Conroy <i>et al</i> <sup>32</sup>	Rural, Kenya	108	98	5–16	3	POU, solar treatment	0.66 (0.50 to 0.87)	Household randomised controlled trial	Solar treatment of drinking water was associated with a reduction in all diarrhoea episodes.
Conroy <i>et al</i> <sup>17</sup>	Rural, Kenya	175	174	<6	3	POU, solar treatment	0.69 (0.63 to 0.75)	Household randomised controlled trial	The odds of having childhood diarrhoea was significantly reduced among children using solar disinfected water.
du Preez <i>et al</i> <sup>30</sup>	Mixed, Kenya	555	534	<5	6	POU, solar treatment	0.70 (0.59 to 0.84)	Household randomised controlled trial	<i>Escherichia coli</i> concentrations did not differ over the follow-up period between control and intervention households. However, <i>E. coli</i> concentrations in SODIS bottles were significantly lower than those in storage containers. IRR for both number of days and episodes of dysentery and non-dysentery diarrhoea were significantly ( $p<0.001$ ) reduced by use of SODIS.
Du Preez <i>et al</i> <sup>29</sup>	Peri-urban, South Africa	383	335	<5	12	POU, solar treatment	0.36 (0.16 to 0.81)	Unblinded randomised controlled trial	No significant difference in geometric mean values of thermotolerant coliforms per 100 mL of water between intervention and control. Dysentery was significantly reduced only in households with higher motivation showing but not for non-dysentery.
Mäusezahl <i>et al</i> <sup>18</sup>	Rural, Bolivia	376	349	<5	12	POU, solar treatment, hygiene education	0.91 (0.64 to 1.30)	Cluster randomised controlled trial	No strong evidence for a practical reduction in diarrhoea was observed among children in the intervention groups.

Continued

Table 1 Continued

Study	Study setting, country	Number of participants enrolled in the trial		Age groups (years)	Follow-up periods (months)	Intervention	Effect size (95% CI)	Study design	Findings
		Intervention	Control						
McGuigan <i>et al</i> <sup>63</sup>	Rural, Cambodia	426	502	<5	12	POU, solar treatment	0.37 (0.29 to 0.48)	Randomised controlled trial	Significant difference in faecal coliform levels was observed between intervention and controls (48 CFU per 100 mL in the control and 6.8 CFU per 100 mL in the SODIS group). The childhood incidence of dysentery and incidence of non-dysentery diarrhoea were reduced among the intervention group.
Rose <i>et al</i> <sup>19</sup>	Urban, India	100	100	<5	6	POU, solar treatment, health education	0.64 (0.48 to 0.86)	Randomised controlled trial	The risk of diarrhoea was reduced by using SODIS.
Hartinger <i>et al</i> <sup>20</sup>	Rural, Peru	250	253	<3	12	POU, solar treatment, hygiene education	0.78 (0.58 to 1.05)	Village level cluster randomised trial	The <i>E. coli</i> geometric mean observed was declined both in intervention and control households The odds of developing diarrhoea were decreased in the intervention group.

POU, Point-of-use; SODIS, solar disinfection.

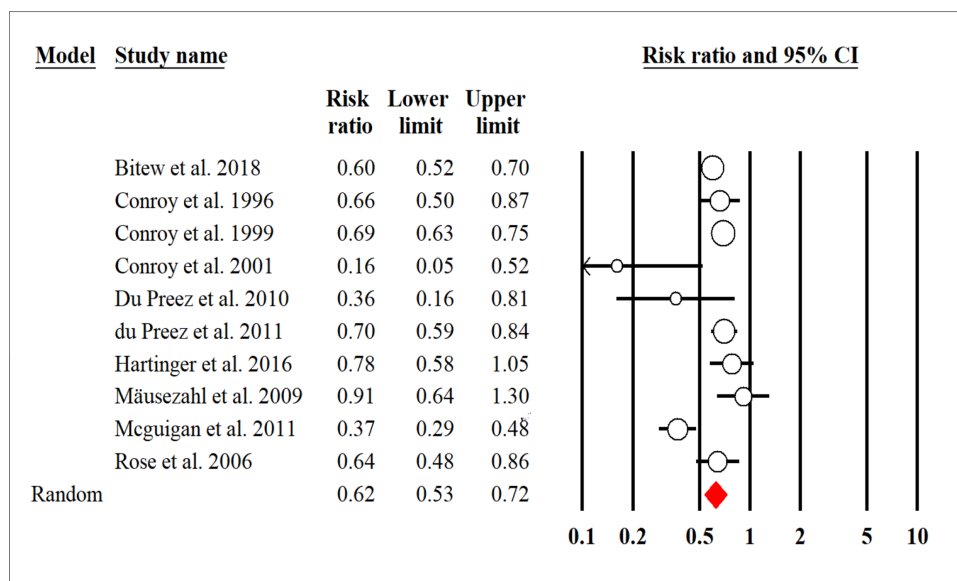


**Figure 2** Tabular representation of risk of bias in individual studies.

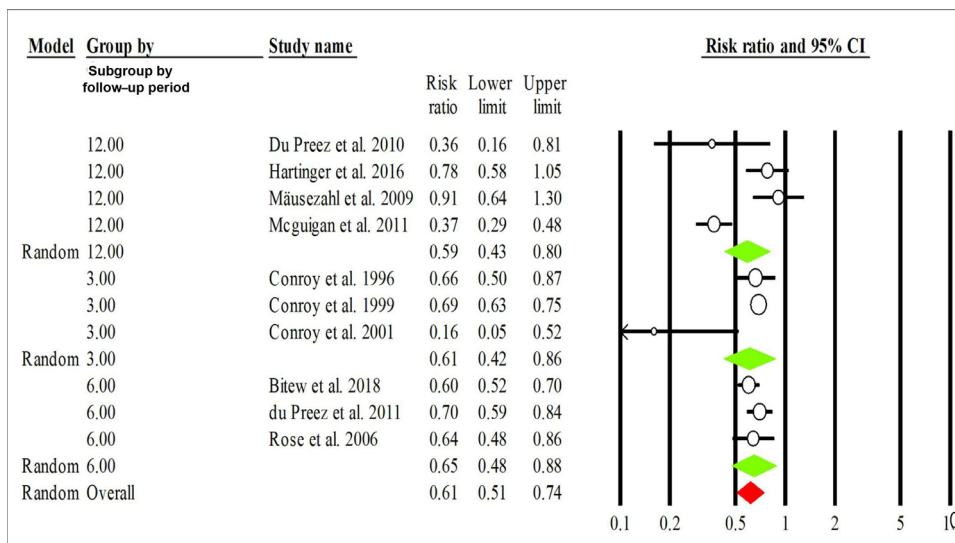
subgroup analysis was computed based on the region of study settings/ continent and presented in [figure 6](#). In the analysis, there is no evidence of heterogeneity for studies from Latin America. The pooled RR of diarrhoea reduction after implementation of the SODIS water treatment method was 37% for studies from Africa (RR=0.63; 95% CI 0.54 to 0.74), 16% for studies from Latin America (RR=0.84; 95% CI 0.62 to 1.13) and 52% for studies from Asia (RR=0.48; 95% CI 0.36 to 0.63) ([figure 6](#)).

### Sensitivity analysis

To identify a single study influence on the overall analysis, a sensitivity analysis was computed using a random-effects model and the results showed that there is evidence for the effect of a single study on the overall meta-analysis. In [table 2](#), the absence of a study done by McGuigan *et al*<sup>33</sup> slightly increased the overall RR to estimate the effectiveness of SODIS on the reduction of childhood diarrhoea. After removing the study by McGuigan *et al*, the



**Figure 3** Forest plot showing pooled risk ratio and corresponding 95% CIs of solar disinfection water treatment to reduce childhood diarrhoea.



**Figure 4** Forest plot showing subgroup analysis: comparing by the length of the follow-up period in months.

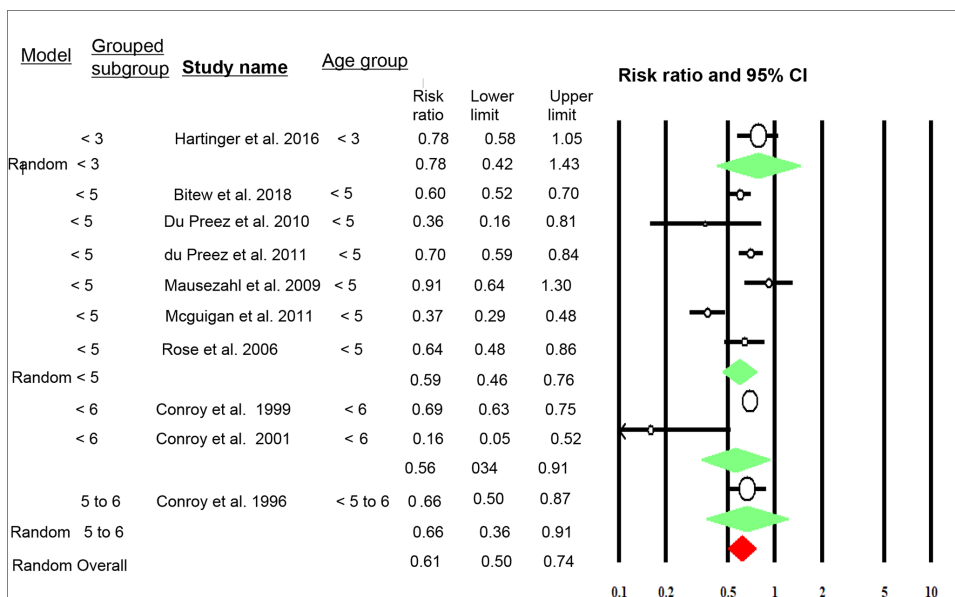
overall pooled RR is slightly increased (0.67 (95% CI 0.60 to 0.75)) and there is no heterogeneity across studies. A statistically significant reduction of diarrhoea occurrence was observed with a risk reduction of 33% after the study by McGuigan *et al*<sup>33</sup> was removed (table 2).

**Publication bias**

Funnel plot and Egger’s statistical test at 95% CI were used to examine the presence of publication bias. The funnel plot was asymmetrical when visually inspected. The likelihood of this funnel plot asymmetry may be related to true heterogeneity or poor methodological quality that led in smaller studies to spuriously inflated effects (figure 7). However, the Egger’s test was not statistically significant at a p value of 0.13. This indicated that there was no statistical evidence of publication bias.

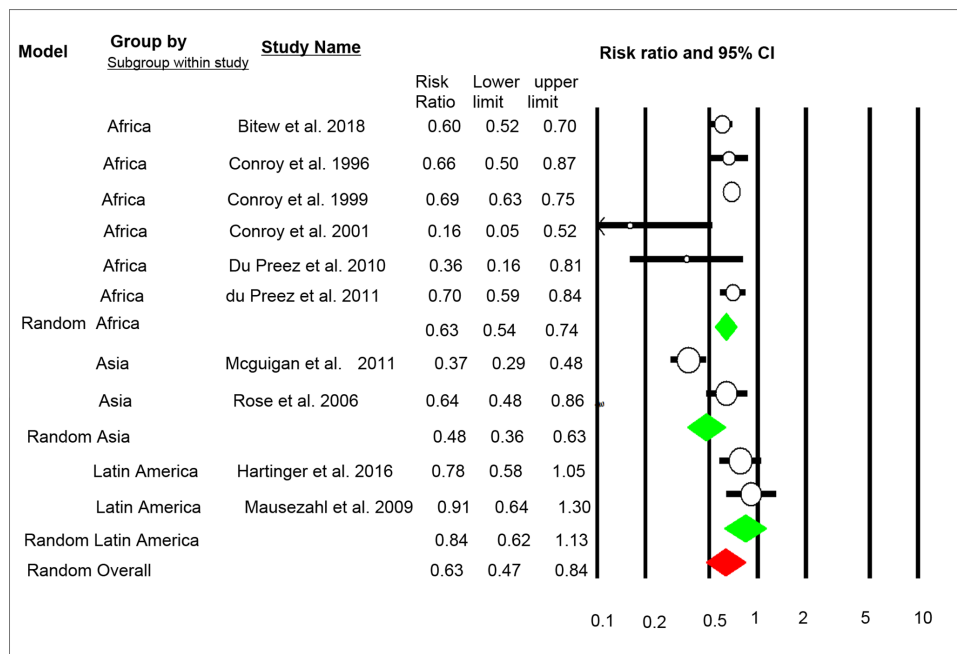
**DISCUSSION**

The analysis demonstrates the effectiveness of the SODIS water treatment method for the prevention of diarrhoea. The overall pooled RR indicated a 38% reduction of diarrhoea through SODIS water treatment methods (RR=0.62; 95% CI 0.53 to 0.72). A systematic review of improving water quality intervention for preventing diarrhoea study done by Clasen *et al* also reported that the risk of diarrhoea was reduced by 38% using SODIS for all ages (RR=0.62, 95% CI 0.42 to 0.94).<sup>34</sup> A systematic review of the impact of drinking water, sanitation and handwashing with soap interventions to reduce childhood diarrhoea, done by Wolf *et al* report showed a lower reduction of diarrhoeal risk of 12% (RR=0.88; 95% CI 0.60 to 1.27) after adjusting for non-binding using the point-of-use



**Figure 5** Forest plot showing subgroup analysis: comparing by age of study participants.





**Figure 6** Forest plot showing subgroup analysis: comparing by the region of study settings.

solar treatment for the community depending on the unimproved source.<sup>35</sup>

A systematic review of improving water quality intervention for preventing diarrhoea study done by Clasen *et al* also reported that the risk of diarrhoea among children aged <5 years of age was reduced by 45% using point-of-use SODIS.<sup>34</sup> A review of point-of-use drinking water filtration done by Sobsey *et al* also reported that SODIS treatment significantly decreased diarrhoeal disease in children in Africa and India, with reductions of 26%–37%.<sup>36</sup> Similarly, in our study subgroup analysis of children aged <5 years of age, the risk of diarrhoea was reduced by 41% using the SODIS water treatment method. The similarity of the results might be the overlap of the included studies, that is, 6 out of 10 studies included in the pooled

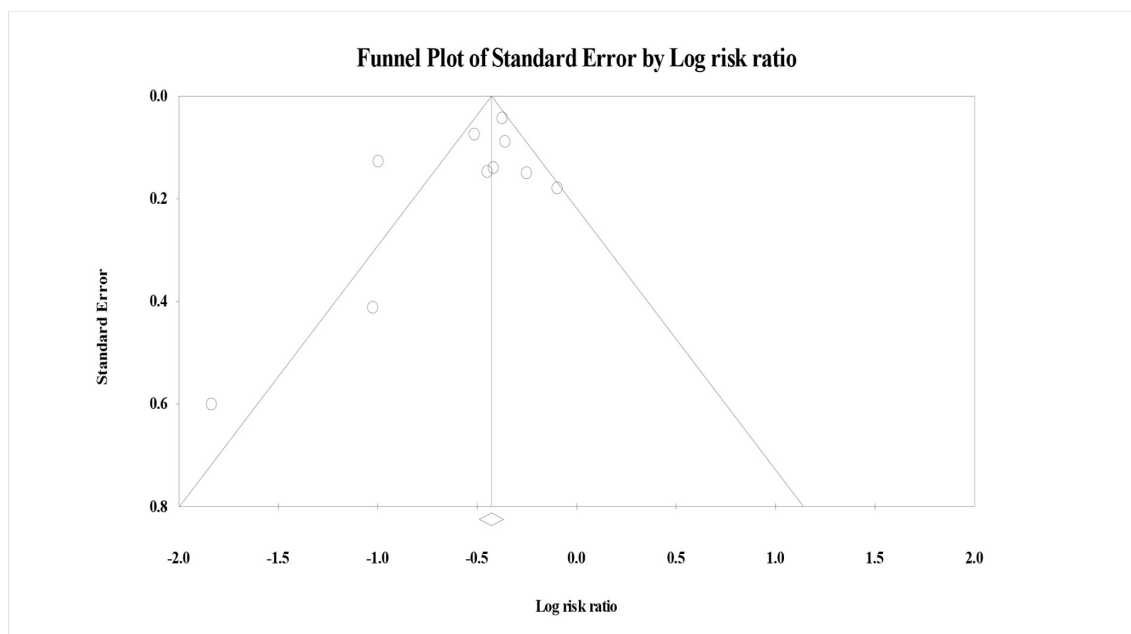
estimate calculated by Clasen *et al* were also included in this analysis.<sup>17 18 29 30 32 33</sup>

The results of our meta-analysis are nearly consistent with a systematic review of water, sanitation and hygiene interventions to reduce diarrhoea in low-income countries, done by Fewtrell *et al*, where a pooled effect for household water treatment only improved the risk of diarrhoea by 35%.<sup>6</sup> However, this study finding showed a stronger effect of SODIS than the pooled meta-analysis results of the study done to demonstrate the effect of point-of-use chlorine treatment on child diarrhoea, which indicated the effect of diarrhoea was reduced by 29% after the intervention.<sup>37</sup> Our study findings also showed a stronger effect of SODIS than other methods of water disinfection reports which showed point-of-use chlorine treatment

**Table 2** Sensitivity analysis of the effectiveness of SODIS water treatment method for the reduction of childhood diarrhoea

Article removed in the analysis	Number of studies included	Random-effects pooled risk ratio (95% CI)	Q-value	Q-test p value	I <sup>2</sup> (%)
Bitew <i>et al</i> (2018)	9	0.62 (0.52 to 0.74)	33.69	<0.0001	76.26
Conroy <i>et al</i> (1996)	9	0.61 (0.52 to 0.73)	35.10	<0.0001	77.21
Conroy <i>et al</i> (1999)	9	0.60 (0.49 to 0.73)	31.87	<0.0001	74.89
Conroy <i>et al</i> (2001)	9	0.63 (0.55 to 0.73)	29.75	<0.0001	73.11
du Preez <i>et al</i> (2011)	9	0.61 (0.51 to 0.72)	34.39	<0.0001	76.74
Du Preez <i>et al</i> (2010)	9	0.63 (0.54 to 0.73)	33.04	<0.0001	75.79
Mäusezahl <i>et al</i> (2009)	9	0.59 (0.51 to 0.70)	31.59	<0.0001	74.67
McGuigan <i>et al</i> (2011)	9	0.67 (0.60 to 0.75)	14.55	0.0690	45.01
Rose <i>et al</i> (2006)	9	0.62 (0.52 to 0.73)	35.09	<0.0001	77.21
Hartinger <i>et al</i> (2016)	9	0.60 (0.51 to 0.71)	33.63	<0.0001	76.21

SODIS, solar disinfection.



**Figure 7** Funnel plot of studies included in the analysis of the effectiveness of solar disinfection on the reduction of childhood diarrhoea.

to have reduced the risk of diarrhoea by 9% among the community using the unimproved source water supply.<sup>35</sup> The discrepancy could be due to the difference in the study sample size or the length of the follow-up period of the interventions or study design.

However, compared with a review of point-of-use drinking water filtration done by Sobsey *et al* where the risk of diarrhoea reduced by 46%–63% using different types of filtration drinking water treatment methods,<sup>36</sup> our finding was less. A systematic review and meta-analysis done by Cohen and Colford showed boiling the drinking water before consumption also affects childhood diarrhoea.<sup>38</sup> Our findings are also consistent with these results, although a direct comparison is difficult because they report results ranked by the measure of ORs rather than the RRs.

The evidence from this meta-analysis shows that there is a reduction in improvement in the risk of diarrhoea and the studies included were homogenised at 6 months follow-up compared<sup>16 19 30</sup> with those followed for 3 months and 12 months.<sup>17 18 20 29 31–33</sup> The difference could be assumed that the 3 months follow-up of the interventions was not long enough to get any great significant changes comparatively. The use of SODIS for water treatment has a limitation as it requires safe storage after disinfection since the intervention provides no residual disinfectant.<sup>38 39</sup> Similarly, in the 12 months of follow-up, the motivation of participants for safe storage might be lowered over time.

This meta-analysis has some limitations. First, we tried to include only published articles, excluding unpublished articles/resources. The restriction to studies written in the English language was another limitation of this meta-analysis. In addition, the differences in the study settings

(urban or rural) or the environments under which the intervention was carried out were also a limitation of this study. The other limitation of this analysis was that we used a limited number of studies.

In conclusion, the results of this systematic review and meta-analysis showed that the intervention of SODIS water treatment had significantly reduced the risk of childhood diarrhoea. There was some bias, but after sensitivity analysis, the effect was still apparent. The exclusion of one study reduced the heterogeneity. Further high-quality studies are needed to definitively determine whether SODIS water treatment is an important method to reduce childhood diarrhoea. Our meta-analysis will need to be updated as the results of future studies become available.

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